THE OHIO JOURNAL OF SCIENCE

VOL. XXIV JANUARY, 1924 No. 1

A TAXONOMIC, ECOLOGIC AND ECONOMIC STUDY OF OHIO APHIDIDÆ.*

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INTRODUCTION.

The Aphididæ constitute a very interesting group of insects. From a biological point of view their peculiar mode of reproduction, together with their complicated life cycle give them special interest among insects. The taxonomy of the family is very much complicated because of the great variation of forms which occur even within the same species. The annual loss occasioned by the feeding habits of the family places the group in a major position economically.

The author began the study of the family in the summer of 1915 while a student at Ohio State University, Lake Laboratory, Cedar Point, Ohio. Since that time much time has been spent in collecting, mounting and identifying species, together with field work in study and control of several destructive species. Special study was made of the life cycle of *Macrosiphum solanifolii* for one season while the author was employed as an assistant at Ohio Agricultural Experiment Station. In this study attention was given to the seasonal change of host plants of this species and factors which seemed to affect migration.

Collections were followed with color notes of the species. In addition to the Ohio forms studied, over two hundred species

* Dissertation presented in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in the Graduate School of the Ohio State University.

collected in Pennsylvania have been studied and color notes and habit descriptions made. These notes are much too lengthy to include in this work, but it is expected that they may be incorporated in future papers dealing with the group. The following outline has proven of much help in making and keeping records of collections:

Name	Number
Place of Collection	Date
Collector	Ants attending
Host plant	Notes
Literature	

On the reverse side of the sheet is an outline for color notes:

General color	Head
Thorax	Abdomen
Antennæ	Legs
Wings	Cornicles
Cauda	Notes

The author finds a five by eight loose-leaf note book opening lengthwise satisfactory for this outline.

Each collection is given a number which is recorded on the note sheet and on each slide mount made. This same number may be used for insects taken in association with the Aphid species.

For the most part the species collected have been mounted directly into balsam without special clearing. In place of xylol, which is usually used as a solvent for the balsam, the author prefers toluene, since it seems to serve as a better clearing agent than the xylol and the mounts dry more quickly. The balsam is made quite thin by the addition of toluene and a drop placed on a clean microscope slide. The living aphid is then placed in this drop, and after wetting with a small drop of toluene is spread to show body parts. The cover glass is put in place and the space well filled with balsam.

The slides are then placed in a drying oven kept at a temperature of from 40 to 45 degrees C. Certain dark-colored species must be cleared before permanent mounts are made. In fact, many workers in the group are now clearing all their specimens in potassium hydroxide before mounting.

The literature for the Family has been reviewed and the source of latest information as to synonymy and the like for each species is inserted after the name of the species in the list given for the state.

ACKNOWLEDGMENTS.

The author is indebted to many persons for help in this work. Mr. P. R. Lowry, New Hampshire Agricultural College, collected many specimens and made several color descriptions. Professor H. A. Gossard, Ohio Agricultural Experiment Station, gave many helpful suggestions, and gave liberally of time in helping in this study. Doctor A. C. Baker, United States Department of Agriculture, identified many species, and checked over identifications made by the author, giving most freely of his time and knowledge. Doctor R. C. Osburn, Head of the Department of Zoology and Entomology, Ohio State University, gave much encouragement and aid. Professor J. G. Sanders, Director of Pennsylvania Bureau of Plant Industry, has offered every facility for the pursuit of this study and has always stood ready to aid. He has given valuable aid in reading and criticizing this manuscript. To all these the author gives his hearty thanks. To Doctor Herbert Osborn, Ohio State University, under whom this work has been done, special thanks are due for aid and encouragement, and for his enduring belief in the author's ability to pursue the work. To him would I dedicate this work.

TAXONOMY.

The family Aphididæ belongs to the Order Hemiptera, Suborder Homoptera of the Class Insecta. The Homoptera are divided into two groups according to the manner in which the rostrum is placed in relation to the sternum of the prothorax. First, the families with the rostrum free from the sternum known as the Auchenorhynchi. This group embraces the families Cicadidæ, Fulgoridæ, Membracidæ, Cercopidæ, and Cicadellidæ. The second group is made up of the families in which the beak is fused with the sternum of the prothorax, known as the Sternorhynchi, embracing the families Psyllidæ, Aphididæ, Aleurodidæ, and Coccidæ.

Relationships of the families of the Sternorhynchi will be discussed under the following topics: General body shape, structure and position of the rostrum, antennal comparison, leg structure, presence of wax glands, wing venation, and reproduction.

General Body Shape.

In general body shape the Psyllidæ closely approach the Cicadidæ, and it would seem as though some Cicada-like stock gave rise to the Psyllid group. Certain mature forms of the family Aleurodidæ have a resemblance to Psyllidæ. This type form has been greatly modified in the nymphal forms of the family where sedentary habit and coccid-like forms are associated. Aphididæ show less divergence from the Psyllid type than do the Aleurodidæ, and excepting the dimorphs of certain forms (*Periphyllus* sp. and others) and scale-like individuals belonging to the genera Chermes, Cerataphis, and Phylloxera, the developing nymphs resemble the adults in body form. The Coccidæ have digressed farthest from the primitive ancestral stock of the Sternorhynchi; this is particularly marked in the females of the Diaspinæ. Loss of body parts and change in general shape is marked throughout the family, undoubtedly associated with the more or less sedentary habits of the species.

Morphology and Position of the Rostrum.

The rostrum of the Psyllidæ is long, though never as long as the body, and is composed of three segments. It is of the ordinary Hemipterous type. In the Aphididæ the segments of the rostrum number four or five, and this segmentation is characteristic of the family, this number not occurring in other families of the Hemiptera. The rostrum has shortened in the Aleurodidæ and is composed of three segments, while with the Coccidæ there is a sex difference in the structure of the rostrum. In the male it is usually spoken of as being absent, but it is represented by a minute triangular projection, the labium; while in the female the rostrum is well developed. Here the mandibles and maxillæ are bristle-like and often much longer than the body. Mouth-parts are lacking in adult females of the two subfamilies Margarodinæ and Xylococcinæ.

Antennal Condition.

Well developed, filiform antennæ are always present in the Psyllidæ. The segments tend to be uniform in size and are from nine to twelve in number, and are without sensoria. The attachment to the head is in front of and somewhat below the eyes. Antennæ are always present in the Aphididæ, attached to the front of the head. They are usually somewhat

conspicuous and consist of from three to six segments, with the last segment frequently fitted with a filamentous prolongation or spur. Sensoria and sensilia are characteristic of the aphid antennal segments. The sensoria are probably organs of special sense, and their position, number and shape are of generic and specific significance. Antennæ are always present in the Aleurodidæ, attached to the front of the head. Sensoria are lacking. The presence or absence, and number of segments in the antennæ of the members of the family Coccidæ depends upon the genus and sex of the individual. With the male the organs usually are present and made up of about ten segments, with attachment to the front of the head. With the female the antennæ may be composed of as many segments as the male or the number may be greatly reduced. Attachment is to the under side of the body. Sensoria are lacking in both sexes.

Leg Structure.

Associated with the jumping habit of the Psyllidæ are the swollen hind femora. The tarsi are two-jointed. The legs of Aphididæ are long and slender, except in dimorphic forms and the Phylloxerina where the legs are greatly shortened, suggesting the condition found in the Coccidæ. Typically there are two tarsal segments in the Aphididæ though in the genus Mastopoda both segments and claws are lacking.

Legs are always present in the adult Aleurodidæ, but are lacking in the nymphal forms. In the late nymphal stage the developing legs of the adult may be seen on the ventral side of the body, but are within the insect's pupal case and non-functional. Male Coccidæ have well developed legs, fitted with single jointed tarsi which terminate in a single claw. The males of two species of the genus *Exaeretopus* are exceptions to the above, and bear tarsi of two segments. The female of some genera of Coccidæ bear legs while in other genera they do not. Ordinarily their legs do not project beyond the sides of the body. Tarsi are, as in the male, single jointed and single clawed.

Wax Glands.

Wax secreting glands are found in all the families of the Sternorhynchi. In Psyllidæ oval wax glands are found in the adult *Trioza salicis*. Abdominal and marginal glands are

found in nearly all nymphal stages. These marginal pores secrete long fine hollow waxen hairs which sometimes form a conspicuous fringe about the insect. Some nymphal forms of Aleurodidæ have wax pores of different types, such as simple, agglomerated, and compound. Dorsal pores are present and are always simple, and may be arranged in definite rows producing a ring comparable to that in the nymphal form of Psyllidæ. In the Aphididæ the wax glands are grouped. Eriosoma and some Pemphigus show a simple ring grouping, while in the Chermes and Mindarus the pores have agglomerated, and in some instances are surrounded by a chitinized ring. Secretion of wax is most marked in the mature forms. Wax secretion and wax pores probably reach the greatest development in the Coccidæ, forming the greater part of the armor of soft scales. The freshly hatched nymph shows no signs of waxy secretions, but eventually waxen threads start growing over the whole of the body surface. The development of wax probably is most pronounced in the genera Ceroplastes and certain Tachardias. The production of wax increases with the increase of sedentary habit in the families of the group. The protection offered by the wax has undoubtedly added much to the success of the families in the protection afforded from enemies and adverse weather conditions.

Wing Venation.

The entire discussion of wing tracheation and venation is based on the work of Doctor Edith M. Patch "Homologies of the Wing Veins of the Aphididæ, Psyllidæ, Aleurodidæ and Coccidæ," Vol. II, p. 101-129, An. Ent. Soc. of Amer.

There is a specialization in the group through the loss of parts of wings even to their total loss. Adults of the family Psyllidæ always bear two pairs of wings. Nymphal tracheation shows seven tracheae in the fore wing as follows: Costal, subcostal, radial, medial, cubital, first anal and second anal. Newly emerged wings show the following condition: Costal tracheation has disappeared, subcostal tracheae have migrated to near the costal margin, the proximal one-fourth of the radial, medial, and cubital tracheae have coalesced, the first anal follows the course of the claval suture, while the second anal has migrated to near the anal margin.

Mature forms of the family Aphididæ may be either winged or wingless in the same species; or entirely without wings, so far as is known, throughout the life cycle. The wings for the most part are clear, and always consist of two pairs, with the front pair considerably larger than the hind pair. Aphididæ in the more generalized genera have four nymphal tracheae: Radial, medial, cubital and first anal. In the newly developed wing the tracheae are reduced to two, one carrying the radial and radial sector; the other the medius, cubitus and anal. The costa and subcosta are probably not preceded by tracheae. In the Chermes, a genus probably showing specialization, there seems to be an unstable condition of tracheation from two basal tracheae to a single basal trachea. In newly emerged Chermes wings the radius has disappeared and the radial sector has straightened out to occupy the caudal margin of the stigma; the medius has migrated to the position usually occupied by the radial sector.

The wings of the Aleurodidæ are always four in number. The venation is greatly reduced. There are four pairs of the fine but distinct tracheae, the costal, subcostal, radial and cubital; all extending separately to the base of the wing. The medial trachea is indicated by a very faint tracing in the wing. In the definitive venation of the fore wing the costa, subcosta, veins radius one and the media are lacking; only the main stem of the radius and radial sector, and cubitus are developed. The hind wing has but one vein which is probably the radius and radial sector.

Wings are lost in the Coccidæ except in the male, where they are represented by a single pair (the fore pair, the hind wings being represented by a pair of hooks). Tracheation of the wings in the male of Dactylopius is represented by four distinct tracheae. These tracheae remain distinct until after the veins have begun to form so that the relation of the two is at once seen. There seems no necessary connection between the tracheae and the veins which are found later.

Reproduction.

Reproduction becomes more specialized from the Psyllidæ to the Coccidæ. Psyllidæ reproduce oviparously and as a rule are single brooded in a year. Aleurodidæ reproduce oviparously with two or more broods each year. In the Aphididæ reproduc-

tion may be oviparously, or viviparously and parthenogenetically, or oviparously and parthenogenetically. In a great number of genera several viviparous parthenogenic generations follow one after the other throughout the favorable growing season, and upon the arrival of a season of unfavorable growth produce "true sex" forms, the females of which after copulation lay the overwintering eggs. From these eggs hatch young which are all females—the beginning of the viviparous parthenogenetic generation—the "stem mothers." Coccidæ reproduce oviparously, viviparously and a few probably parthenogenetically; and with several generations each year.

Viviparous and parthenogenetic conditions have arisen independently in the different families as we have in each family primitive oviparous forms showing that this habit was retained until after the separation of the different family offshoots from the common stock.

Summary of Relation of Families of Sternorhynchi.

From the foregoing topical comparisons it is evident that the Psyllidæ are nearest to the primitive ancestral form from which the Sternohynchal stem branched. The resemblance in body form and organ structure of the Psyllidæ to the less specialized Auchenorhynchi is quite marked. As shown under the discussion of wing venation and wing structure there is a specialization from the well developed wing condition of Psyllidæ to a wingless condition, as found in certain Aphididæ and Coccidæ.

The families Aleurodidæ, Aphididæ and Coccidæ are further removed from the ancestral stock showing sepcialization through loss of body parts associated with the sedentary life habits, and the departure from the primitive or true Hexapod mode of reproduction.

From the stem of the primitive ancestral form the Psyllidæ were the first to branch off and the other families diverged higher up on the stem, the three at about the same time, each specializing in its own way; the Aphididæ in the matter of reproduction, development of antennal sensoria, abdominal cornicles and beak segmentation; the Aleurodidæ in greatly specialized nymphal forms; the Coccidæ in loss of body parts and in specialized reproduction.

CHARACTERISTICS OF THE APHIDIDÆ.

At present there are about eight or ten hundred described species of Aphididæ. The members of the family may be characterized as follows: Body soft, more or less oval, appendage tending to be long and slender, wings when present membraneous and two pairs in number, mouth parts sucking in type, antennal segments from three to six, segments bearing sensoria and sensilia, tarsi two-jointed, abdomen bearing on the fifth segment a pair of dorsi-lateral cornicles, reproduction both by parthenogenesis and amphigony.

CLASSIFICATION OF THE APHIDIDÆ.

In this work the Family Aphididæ is divided into five subfamilies as follows: Aphidinæ, Mindarinæ, Hormaphidinæ, Eriosomatinæ and Phylloxerinæ. Dr. A. C. Baker in his work on generic classification* set up a superfamily Aphidoidea and separated this into two families, Phylloxeridæ and Aphididæ. This classification to the writer seems unnecessary and adds to confusion in the group. It seems evident to the writer that the Phylloxerinæ comprise the more specialized group of the family. The parthenogenetic oviparous mode of reproduction of the Phylloxerinæ probably developed from the parthenogenetic viviparous mode of the other subfamilies, and may be considered an advance over the other subfamilies. The loss of body parts has gone farther in the Phylloxerinæ, as shown in the loss of antennal segments, probable loss of cornicles, modification and loss of wing venation, than in the other subfamilies. There is a similarity in the galls formed by the Phylloxerina and those of Hormaphidinæ and wax plates and glands are evident in the subfamily. The sex forms of the genus Phylloxera are quite suggestive of Eriosomatinæ in being beakless, apterous, dwarfed in size and the female laying a single fertilized egg.

The key to the subfamilies, using Baker's work as a basis, would be as follows:

Key to the Subfamilies of the Aphididae.

1. "Summer parthenogentic oviparous forms produced. Stigma formed by the radial sector.....Phylloxerinæ
   Only sexual oviparous forms produced, stigma formed by radius.....2

* Bull 826, U. S. D. A. 1920, p. 2.

2. "Sexual forms small with functioning mouth parts absent. Oviparous females with all the egg tubes present or indicated in the embryo but the adult possessing only one tube and maturing one cell so that one egg only is laid. Cornicles much reduced or absent. Wax glands abundantly developed. Wind veins usually reduced. Antennal sensoria prominent. Eriosomatinæ

"Sexual forms with functioning mouth parts. Nearly all the ovarian tubes developed in the adult oviparous female.....3

3. Radial sector of forewing inserted mesad of the stigma. Sexes small. Oviparous female laying several eggs.....Mindarinæ

Radial sector not so inserted, but arising from the stigma.....4

4. "Forms usually gall makers. Wing veins much reduced so that the media is usually simple. Wax glands usual. Antennal sensoria annualar, Aleurodiform stages common. Sexes wingless as a rule and small..Hormaphidinæ

"Forms not usually gall makers. Wing veins often not reduced. Wax glands not abundant. Antennal sensoria oval or subcircular. Aleuridiform stages rare. Cornicles often little reduced. Winged males common. Aphidinæ

Baker's keys to the genera of the four subfamilies Eriosomatinæ, Mindarinæ, Hormaphidinæ and Aphidinæ have been followed in classification.

The Subfamily Phylloxerinæ is characterized as follows:

Biological characters: Gall forming on conifers and the leaves of deciduous trees and woody plants. Reproduction so far as known entirely by eggs.

Morphological characters: Radial sector of wing forming the caudal margin of the stigma; the radius has disappeared and the media has taken the place occupied by the radial sector in the more generalized groups. Fundatrix with three antennal segments. Cornicles wanting.

The subfamily may be separated into two tribes by the following key:

1. Cubitus arising from the first anal vein about one-third distance from its proximal end. Gonapophysis absent.

Gall forming on the leaves of deciduous trees and woody plants..... Tribe Phylloxerini

Cubitus arising from stigma independent of the anal vein.

Gonapophysis represented by three short cone-like bodies. Found on conifers. Tribe Chermisini

Tribe *Phylloxerini*

Biological characters: Most species gall forming on leaves and roots of deciduous trees and woody plants. Reproduction by eggs. Sexual forms known.

Morphological characters: Head rounded in front; thoracic region broad; abdomen somewhat conical in the alate. Antennæ short with three segments, the third being much the longer. Beak moderately long; absent in the sexuals. Wings rather large, cubital arising from the first anal. Tarsal sensilla long and capitate. Cornicles wanting. The tribe embraces the genus Phylloxera Boyer with *P. quercus* Boyer as type.

Tribe Chermisini.

Biological characters: Found on coniferous trees and at times causing galls on the host plant. Reproduction by parthenogenetic oviparous eggs only. Male form not definitely known.

Morphological characters: Apteræ with broad oval body. Antennæ very short and three jointed. Legs short and stout. Beak stout and with very long setæ. Entire body with a large number of glandular patches. Antennæ of alate apparently of five segments. Head very broad. Suckers at distal end of tibiæ. Cubitus arising from stigma independent of the anal vein. Gonapophysis represented by three short cone-like bodies.

The tribe embraces the genus Chermes Linn. with *C. abietis* Linn. as type.

List of Ohio Species.

The known Ohio representatives of the family Aphididæ are given in the following list together with bibliographical references as to synonymy, description and life habits.

Subfamily Aphidinæ.

Tribe *Lachnini.*

ANOECINA.

Anoecia querci (Fitch). Ent. News, Vol. 27, p. 359. In migration. Winterset, Oct. 20, 1916.*

SCHIZOLACHNINA.

Dilachnus strobi (Fitch). Described as *Lachnus strobus*, now considered as coming in the genus Dilachnus as defined by Baker. Can. Ent., Vol. 51, pp. 211 and 253. Columbus, Ohio. Reported by H. Osborn.

Schizolachnus rosea (Choldk.). Described as *Lachnus rosea.* European form. On wild rose. Wooster, Ohio. Oct. 29, 1917. Oviparous females taken.

LACHNINA.

Lachnus sp. Identified as a new species by Mr. H. F. Wilson. Specimen retained to be described by himself. Columbus, Ohio. May 21, 1915. W. W. Marshall, Coll.

Longistigma caryæ (Harris). Can. Ent., Vol. 41, p. 385. Common throughout the state in the fall on sycamore (*Platanus occidentalis*).

Tribe *Callipterini.*

PHYLLAPHIDINA.

Phyllapis quercicola Baker. Ent. News, Vol. 27, p. 362, and Vol. 22, p. 241. White oak (*Quercus alba*). Wooster. July 4, 1920. P. R. Lowry, Coll.

Phyllaphis fagi (Linn.) Bul. 826, U. S. D. A., 1920, p. 24. On beech (*Fagus americana*). Wooster. August 19, 1920. P. R. Lowry, Coll.

CALLIPTERINA.

Therioaphis tiliæ (Linn.) Bul. 826, U. S. D. A., 1920, p. 28. On linden (*Tilia americana*). Columbus. October 12, 1916.

Euceraphis mucidus (Fitch). Jr. Ec. Ent., Vol. 10, 1917, p. 425. Sugar Grove. September 3, 1912. W. W. Marshall, Coll.

Monellia caryæ (Monell). Jr. Ec. Ent., Vol. 10, 1917, p. 424. On black walnut (*Juglans nigra*). Winterset. August 11, 1916.

Monellia caryella (Fitch). Jr. Ec. Ent., Vol. 10, 1917, p. 424. On shingle oak (*Quercus imbricaria*). Winterset. August 11, 1916.

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* Species listed without collector name were collected by the author.

Calaphis betuella Walsh. Proc. Wash. Ent. Soc., Vol. 18, 1916, p. 185. On *Betula papyrifera*. Wooster. August 7, 1917.

Calaphis betulaecolens (Fitch). Proc. Wash. Ent. Soc., Vol. 18, 1916, p. 186. On *Betula lutea*. Wooster. September 11, 1917.

Calaphis castaneæ (Fitch). Proc. Wash. Ent. Soc., Vol. 18, 1916, p. 187. On *Aesculus hippocastanum*. Wooster. September 20, 1917.

Calaphis annulata (Koch.). Jr. Ec. Ent., Vol. 10, p. 427. On *Betula alba*. Wooster. August 7, 1917.

Myzocallis asclepiadia (Monell). Jr. Ec. Ent., Vol. 10, p. 423. On milkweed (*Asclepias syrica*). Kirkersville. October 12, 1915.

Myzocallis bellus (Walsh). Jr. Ec. Ent., Vol. 10, p. 423. On black oak (*Quercus velutina*. Wooster. September 14, 1917.

Myzocallis discolor (Monell). Jr. Ec. Ent., Vol. 10, p. 423. On swamp oak (*Quercus bicolor*). Wooster. September 20, 1917.

Myzocallis punctatellus (Fitch). Jr. Ec. Ent., Vol. 10, p. 423. On chestnut (*Castanea dentata*). Wooster. September 19, 1917.

Myzocallis punctatus (Monell). Jr. Ec. Ent., Vol. 10, p. 423. On swamp oak (*Quercus bicolor*). Kirkersville. October 2, 1915.

Myzocallis tiliæ (Linn.). Jr. Ec. Ent., Vol. 10, p. 423. On linden (*Tilia americana*). Wooster. September 20, 1917.

Myzocallis ulmifolii (Monell). Jr. Ec. Ent., Vol. 10, p. 423. On elm (*Ulmus americana*). Wooster. September 15, 1917.

Myzocallis walshi (Monell). Jr. Ec. Ent., Vol. 10, p. 423. On hickory (*Carya glabra*). Winterset. August 11, 1916.

DREPANOSIPHINA.

Drepanaphis acerifoliæ (Thomas). Bul. 826, U. S. D. A., 1920, p. 31. On maple (*Acer saccharum*). Columbus. May 14, 1916.

Drepanaphis monelli (Davis). An. Ent. Soc. Amer., Vol. 2, p. 197. On *Aesculus glabra*. Columbus. October 26, 1922. J. T. Potgieter, Coll.

Neosymydobius albasiphus (Davis). Bul. 826, U. S. D. A., p. 32. On white oak (*Quercus alba*). Winterset. August 11, 1916. Determined by J. J. Davis.

CHAITOPHORINA.

Chaitophorus viminalis Monell. Jr. Ec. Ent., Vol. 10, 1917, p. 429. On *Salix* sp. Toledo. October 11, 1917.

Periphyllus negundinis (Thomas). Bul. 826, U. S. D. A., 1920, p. 34, and Bul. 173, Ia. Agr. Exp. Sta., 1917. On box elder (*Acer negundo*). Columbus. September 3, 1916.

Neothomasia populicola (Thomas). Bul. 826, U. S. D. A., 1920, p. 35. On *Populus* sp. Winterset. August 8, 1916.

Sipha flava Forbes. Tech. Bul. 12, part 8, U. S. D. A., 1909, p. 156. On sorghum. Batavia. July 30, 1917.

PTEROCOMMINA.

Pterocomma bicolor (Oest.). Jr. Ec. Ent., Vol. 10, p. 431. On *Salix* sp. Rock Bridge. September 30, 1917. P. R. Lowry, Coll.

Pterocomma flocculosa (Weed). Jr. Ec. Ent., Vol. 10, p. 431. On *Salix nigra.* Wooster. October 22, 1917. J. S. Houser, Coll.

Pterocomma populæ (Kalt.). Jr. Ec. Ent., Vol. 10, p. 431. On *Bromus* sp. Sugar Grove. October 20, 1912. W. W. Marshall, Coll.

Pterocomma smithiæ (Monell). Jr. Ec. Ent., Vol. 10, p. 431. On *Salix alba vitellina.* Wooster. October 22, 1917. J. S. Houser, Coll.

Tribe *Aphidini.*

APHIDINA.

Anuraphis[1] *prunicola* (Kalt.). Farmers Bul. 1128, U. S. D. A., p. 28. On peach foliage. Toledo. October 11, 1917.

Anuraphis bakeri (Cowen). Farmers Bul. 1128, U. S. D. A., p. 12. On red clover. Common throughout state.

Anuraphis cardui (Linn.). Farmers Bul. 1128, U. S. D. A., p. 17. On thistle (*Cnicus lanceolatus*). Winterset. October 20, 1916.

Anuraphis crataegifolia (Fitch). Pro. Biol. Soc., Washington, Vol. 32, p. 185. On *Crataegus* sp. Sugar Grove. October 20, 1912. W. W. Marshall, Coll.

Anuraphis maidiradicis (Forbes). Seventeenth Rept. Ill., 1891, p. 64. Roots of corn. Winterset. August, 1916.

Anuraphis persicæ-niger (Smith). Farmers Bul. 1128, U. S. D. A., p. 26. Common on peach roots throughout the state.

Anuraphis roseus Baker. New name for *Aphis sorbi.* Can. Ent., Vol. 53, p. 95, and Cornell Univ. Agr. Exp. Sta. Memoir 24. On apple. Common throughout the state.

Anuraphis middletoni (Thomas). Univ. Calif. Tech. Bul., Vol. 3, No. 1, 1919, p. 115. On the roots of *Erigeron canadense.* Cedar Point. July 29, 1915.

Aphis asclepiadis Fitch. Jo. Ec. Ent., Vol. 3, p. 482. On *Asclepias* sp. Cedar Point. July, 1916.

Aphis atriplicis Linn. Univ. Calif. Tech. Bul., Vol. 3, No. 1, p. 93. On curly dock. Columbus. June 6, 1917.

Aphis carduella Walsh. Geol. and Nat. Hist. Survey of Minn. Bul. 4, p. 59. On *Cnicus lanceolatus.* Wooster. October 31, 1917.

Aphis cephalanthi Thomas. Bull. Ill. Lab. of Nat. History, Vol. 10, article 2, p. 112. On *Cephalanthus occidentalis.* Cedar Point. July 15, 1912. W. W. Marshall, Coll.

Aphis cerasifolii Fitch. Bul. 233, Me. Agr. Exp. Sta., p. 260. On choke cherry (*Prunus virginiana*). Cedar Point. August 6, 1915.

Aphis coreopsidis (Thomas). Jr. Ec. Ent., Vol. 3, p. 483. On *Bidens bipinnata.* Kirkersville. October 2, 1915.

Aphis cornifoliæ Fitch. Univ. Calif. Tech. Bul., Vol. 3, No. 1, p. 100. On cultivated sunflower. Wooster. September 19, 1917.

Aphis eupatorii Oest. Bul. 4, Geol. and Nat. Hist. Survey, Minn., p. 59. On boneset (*Eupatorium perfoliatum*). Cedar Point. August 4, 1915.

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[1] The genus Anuraphis is now being monographed by Dr. A. C. Baker of U. S. D. A.

Aphis folsomii Davis. Jr. Ec. Ent., Vol. 3, p. 485. On Virginia creeper (*Psedera quinquefolia*). Wooster. August 2, 1917.

Aphis frondosæ Oest. Bul. 4, Geol. and Nat. Hist. Survey, Minn., p. 67. On *Bidens frondosa*. P. R. Lowry, Coll.

Aphis gossypii Glover. Bul. 257, Tex. Agr. Exp. Sta. On cultivated cucumbers throughout the state.

Aphis heraclella Davis. (N. N. for *A. heraclii* Cowen). Can. Ent., Vol. 51, p. 228. On *Cicuta maculata*. Wooster. September 13, 1917.

Aphis helianthi Monell. Jr. Ec. Ent., Vol. 3, p. 485. On sunflower (*Helianthus* sp.). Bond Hill. October 13, 1917.

Aphis illionoisensis Shimer. Jr. Ec. Ent., Vol. 3, p. 485. On cultivated grape throughout the state.

Aphis lutescens Monell. Jr. Ec. Ent., Vol. 3, p. 487. On *Asclepias* sp. Columbus. October 17, 1916.

Aphis maidis Fitch. Jr. Ec. Ent., Vol. 3, p. 487. On corn. Common throughout the state. Always above ground.

Aphis monardæ Oest. Bul. 4, Geol. and Nat. Hist. Survey, Minn., p. 58. On *Monarda* sp. Cedar Point. July 18, 1916.

Aphis oenotheræ Oest. Bul. 4. Geol. and Nat. Hist. Survey, Minn., p. 62. On chrysanthemum in greenhouse. Medina. March 28, 1918.

Aphis pomi De Geer. Memoir 24, Cornell Agr. Exp. Sta., 1919, p. 686. On apple throughout the state. Feeding on new growths.

Aphis rumicis Linn. Bul. 4. Geol. and Nat. Hist. Survey, Minn., p. 61. Common on many host plants (Chenopodium, Rumex, etc.) throughout the state.

Aphis sambuci Linn. Bul. 826, U. S. D. A., 1920, p. 43. On *Sambucus* sp. Kirkersville. October 14, 1916.

Aphis sambucifoliæ Fitch. Univ. Calif. Tech. Bul. Vol. 3, Part 1, p. 123. *Sambucus canadensis*. Wooster. September 21, 1917.

Aphis spiraephila Patch. Bull. 233, Me. Agr. Exp. Sta., p. 270. On spirea. Wooster. July 16, 1920. P. R. Lowry, Coll.

Aphis spiraecola Patch. Bul. 233, Me. Agr. Exp. Sta., p. 270. On *Spiraea Van Houtii*. Columbus. August 27, 1922. J. T. Potgieter, Coll.

Aphis vernoniæ Thomas. Jr. Ec. Ent., Vol. 3, p. 492. On *Vernonia altissima*. Winterset. August 11, 1916.

Aphis viburnicola Gill. Jr. Ec. Ent., Vol. 3, p. 492. On snowball (*Viburnum opulus*). Columbus. May 5, 1917.

Brevicoryne brassicæ (Linn.). Bul. 826, U. S. D. A., p. 45. Common throughout the state on cultivated cabbage and other cruciferous plants.

Cavariella capreæ (Fab.). Univ. Calif. Tech. Bul., Vol. 3, No. 1, p. 132, and Bul. 826, U. S. D. A., p. 46. Cultivated parsnip. Kirkersville. September 15, 1919.

Cavariella pastinacea (Linn.). Univ. Calif. Tech. Bul., Vol. 3, No. 1, p. 133. On honeysuckle. Columbus. May 12, 1916.

Cerosipha rubifolii (Thomas). Jr. Ec. Ent., Vol. 3, p. 492. On blackberry. Winterset. August 18, 1915.

Hyadaphis xylostei Schrk. Bul. 826, U. S. D. A., p. 47. On honeysuckle. Columbus. May 12, 1916.

Hysteroneura setariæ (Thomas). Can. Ent., Vol. 51, p. 228 and p. 268. On *Prunus* sp. Columbus. October 7, 1919. P. R. Lowry, Coll.

Hyalopterus arundinis Fab. Bul. 233, Me. Agr. Exp. Sta., p. 266, and Bul. 826, U. S. D. A., p. 48. On *Phragmites communis*. W. W. Marshall, Coll.

Hyalopterus atriplicis (Linn.). Jr. Ec. Ent., Vol. 5, p. 407 (*Aphis atriplicis*). On *Chenopodium alba*. London. July 25, 1922. J. T. Potgieter, Coll.

Liosomaphis berberidis (Kalt.). Univ. Calif. Tech. Bul., Vol. 3, p. 130. On *Berberis serotina*. Wooster. November 17, 1917. Scott Harry, Coll.

Rhopalosiphum hippophoaes Koch. Univ. Calif. Tech. Bul. Vol. 3, p. 81. On cultivated buckwheat. Wooster. September 12, 1917.

Rhopalosiphum nymphеæ (Linn.). Bul. 826, U. S. D. A., p. 49. On water lily (*Castalia tuberosa*). Columbus. October 17, 1916.

Rhopalosiphum prunifoliæ (Fitch)—"Apple-grain aphid." Memoir 24, Cornell Agr. Exp. Sta. Common on apple and grass throughout the state.

Rhopalosiphum pseudobrassicæ (Davis) — (*Aphis pseudobrassicæ* Davis). Can. Ent., Vol. 46, p. 231. On cultivated turnips. Wooster. October 29, 1917.

Rhopalosiphum rhois Monell. Univ. Calif. Tech. Bul., Vol. 3, p. 86. On *Rhus typhina*. W. W. Marshall, Coll.

Rhopalosiphum rufomaculata (Wilson). An. Ent. Soc. Amer., Vol. 3, p. 323. (*Coloradoa rufomaculata*). On chrysanthemum in greenhouse. Columbus. March 8, 1917.

MACROSIPHNA.

Amphorophora[1] *crataegi* (Monell). U. S. Geol. and Geo. Survey Bull., Vol. V, p. 20. (*Siphonophora crataegi*) on *Crataegus* sp. Wooster. August 2, 1920. P. R. Lowry, Coll.

Amphorophora nabali (Oest.). Geol. Survey Minn., 14 Report, p. 34, 1886, (*Rhopalosiphum nabali*). On *Prenanthes trifoliolata*. Sugar Grove. October 4, 1919.

Amphorophora rubicola (Oest.). Geol. and Nat. Hist. Survey of Minn., 14 Report, p. 27 (*Macrosiphum rubicola*). On black raspberry. Cedar Point. July 15, 1915.

Amphorophora rubi (Kalt). Kaltenbach, 1843. Mon. der Pflansenlause, p. 24. (Aphis rubi). Black raspberry. Dover. July 17, 1922. F. F. Smith, Coll.

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[1] Species of the genus Amphorophora were identified by Mr. P. W. Mason, U. S. D. A., who is now monographing the genus.

Capitophorus tetrarhodus Walker. Hollandischen Blattlause. P. Van der Goot, p. 128, and Bul. 233, Me. Agr. Exp. Sta., p. 269 (*Myzus rosarum*). On rose. Wooster. October, 1917.

Illinoia liriodendri (Monell). Bul. 826, U. S. D. A., p. 56. On tulip tree (*Liriodendron tulipifera*). Wooster. September 20, 1917.

Illinoia pisi (Kalt.). Univ. Calif. Tech. Bul., Vol. 3, p. 66 (*Macrosiphum pisi*). Common on peas and clover throughout the state.

Macrosiphoniella sanborni (Gill). Mem. Ind. Mus., Vol. 6, p. 164, and Can. Ent., Vol. 50, p. 65. On chrysanthemum in greenhouse. Columbus. January 6, 1917.

Macrosiphum erigeronensis (Thomas). Bul. 282, Me. Agr. Exp. Sta., p. 218, and Aphididæ of Neb., p. 76. On *Erigeron canadense*. Cedar Point. July 6, 1914. W. W. Marshall, Coll.

Macrosiphum eupatorii (Williams). Aphididæ of Neb., Williams, p. 77. On *Eupatorium perfoliatum*. Wooster. September 13, 1917.

Macrosiphum gaurœ (Williams). Aphididæ of Neb., Williams, p. 79. On carnation. Columbus. November 2, 1916.

Macrosiphum granarium (Kirby). Jr. Agr. Research, Vol. 7, p. 463. On cultivated oats. Winterset. June 29, 1915.

Macrosiphum lactucæ (Kalt.). Univ. of Calif. Tech. Bul., Vol. 3, p. 65. On lettuce in greenhouse. Columbus. March 6, 1918. P. R. Lowry, Coll.

Macrosiphum luteola (Williams). Bul. 282, Me. Agr. Exp. Sta., p. 218, and Aphididæ of Neb., Williams, p. 82. On *Ambrosia artemisiæfolia*. Winterset. August 20, 1915.

Macrosiphum rosea (Linn.). Bul. 282, Me. Agr. Exp. Sta. Common throughout the state on rose.

Macrosiphum rudbeckiæ (Fitch). Univ. Calif. Tech. Bul., Vol. 3, p. 67. On golden glow (*Rudbeckia laciniata*). Common throughout the state.

Macrosiphum solanifolii Ash. Bul. 27, Va. Truck Exp. Sta., 1919. Common throughout the state on a variety of host plants. "Pink and green potato aphid."

Macrosiphum taraxaci (Kalt.). Univ. Calif. Tech. Bul., Vol. 3, p. 71, and Bul. 282, Me. Agr. Exp. Sta., p. 218. Common on dandelion.

Macrosiphum venaefuscæ Davis. Can. Ent., Vol. 46, p. 77. On *Rumex acetosa*. Wooster. September 15, 1917.

Myzus cerasi (Fab.). Bul. 233, Me. Agr. Exp. Sta., p. 258. On cherry. Common throughout the state.

Myzus circumflexus (Buckton). Univ. Calif. Tech. Bul., Vol. 3, p. 74. On Easter lily in greenhouse. Medina. February 21, 1918.

Myzus houtonensis (Troop). Farm. Bul., U. S. D. A. 1128, p. 34. On cultivated gooseberry. Columbus. June, 1923. D. M. DeLong, Coll.

Myzus persicæ (Sulz.). Univ. Calif., Tech. Bull., Vol. 3, p. 85. Found on many host plants. Common throughout the state. "The green peach aphis."

Myzus plantagineus Pass. Jr. Ec. Ent., Vol. 3, p. 495. On *Plantago major*. Winterset. August 2, 1916.

Myzus ribis (Linn.). Bul. 225, Me. Agr. Exp. Sta., p. 55. On cultivated currant. Winterset. October 20, 1916.

Phorodon humuli (Schr.). Univ. Calif. Tech. Bul., Vol. 3, p. 79. On plum. Winterset. September 13, 1915.

Subfamily Eriosomatinæ.

Tribe *Eriosomatini.*

Eriosoma americana (Riley). Univ. Calif., Tech. Bul., Vol. 3, p. 148. On *Ulmus americana.* Wooster. July 14, 1920. P. R. Lowry, Coll.

Eriosoma crataegi (Oest.). Bul. 4, Geol. and Nat. Hist. Survey, Minn., p. 27. On crataegus. Wooster. July 14, 1920. P. R. Lowry, Coll.

Eriosoma lanigerum (Hausm.). Univ. Calif., Tech. Bul., Vol. 3, p. 149. On apple and elm. Common throughout the state.

Eriosoma rileyi (Thomas). U. S. D. A. Report 101, 1915, p. 15. On *Ulmus americana.* July 27, 1920. P. R. Lowry, Coll.

Colopha umicola (Fitch). Univ. Calif., Tech Bul., Vol. 3, p. 148. On elm. Common throughout the state.

Gobaishia ulmifusus (Walsh). Bul. 181, Me. Agr. Exp. Sta., p. 220. (*Pemphigus ulmifusus*). Slippery elm. Cleveland. July 6, 1920. J. P. Sobey, Coll.

Tribe *Pemphigini.*

Mordwilkoja vagabunda (Walsh). An. Ent. Soc. Amer., Vol. 7, p. 67. On *Populus deltoides.* Cedar Point. June 20, 1915.

Pemphigus burserus (Linn.). Arkiv. for Zoologi, Band 5, No. 14, p. 114, and Bul. 213, Me. Agr. Exp. Sta., p. 78. On *Populus deltoides.* Put-in-Bay. L. L. Huber, Coll.

Pemphigus populi-transversus Riley. Jr. Agr. Research, Vol. 14, p. 577. On *Populus deltoides* and roots of *Barbarea vulgaris.* Columbus. 1917.

Tribe *Melaphini.*

Melaphis rhois (Fitch). Bul. 826, U. S. D. A., 1920, p. 74. On sumac. Sugar Grove. September 1, 1903. H. Osborn, Coll.

Tribe *Prociphilini.*

Neoprociphilus attenuatus (O. and S.). Bul. 202, Me. Agr. Exp. Sta., p. 174. Reported as common on *Similax rotundifoliæ* in Ohio by Jackson.[1]

Prociphilus fraxinifolii (Riley). Bul. 5, U. S. Geol. and Geog. Survey Terr., p. 17, and Bul. 270, Me. Agr. Exp. Sta. On *Fraxinus americana.* Cedar Point. July 6, 1915.

Prociphilus imbricator (Fitch). Proc. Columbus Hort. Soc., Vol. 22, p. 188, and Bul. 270, Me. Agr. Exp. Sta. On beech (*Fagus grandifolia*). Wooster. September 24, 1917.

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[1] Proceedings Columbus Horticultural Society, Vol. 22, p. 214.

Prociphilus tessellata (Fitch). Proc. Columbus Hort. Soc., Vol. 22, p. 183, and Bul. 270, Me. Agr. Exp. Sta. On Alnus. Common throughout the state.

Thecabius populi-conduplifolius (Cowen). An. Ent. Soc. Amer., Vol. 7, p. 61. On *Populus candicans*. Wooster. July 19, 1920. P. R. Lowry, Coll.

Tribe *Fordini*.

Forda olivacea Rohr.? Psyche, Vol. 15, p. 68. In ants nest. Delaware. May 5, 1920. P. R. Lowry, Coll.

Geoica squamosa Hart. Bul. 826, U. S. D. A., p. 79. On wheat roots. New Stark. June 8, 1923. W. G. Stover, Coll.

Subfamily HORMAPHIDINÆ.

Tribe *Hormaphidini*.

Hamamelistes spinosus Shimer, and *Hormaphis hamemelidis* Fitch. Tech. Series Bul. 9, U. S. D. A. Neither of these species have been taken in Ohio, but are quite likely to occur wherever witch-hazel and birch are found. Common in border counties of Pennsylvania.

Tribe *Cerataphidini*.

Cerataphis lataniæ (Licht.). Bul. 826, U. S. D. A., p. 87. On palm (*Pritchardia filifera*) in greenhouse. J. G. Sanders, Coll.

Subfamily PHYLLOXERINÆ.

Tribe *Phylloxerini*.

Phylloxera caryaecaulis Fitch. Proc. Davenport Ac. Sci., Vol. 9, p. 244. On hickory. Worthington. May 31, 1920. P. R. Lowry, Coll.

Phylloxera caryaevenæ Fitch. Proc. Davenport Ac. Sci., Vol. 9, p. 239. On hickory. Worthington. May 31, 1920. P. R. Lowry, Coll.

Phylloxera picta Perg. Proc. Dav. Ac. Sci., Vol. 9, p. 197. On hickory. Wooster. July 4, 1920. P. R. Lowry, Coll.

Phylloxera popularia Perg. Proc. Dav. Ac. Sci., Vol. 9, p. 266. In galls of *Pemphigus populi-transversus* on *Populus* sp. Sandusky. September 10, 1920. P. R. Lowry, Coll.

Phylloxera vitifoliæ (Fitch). Bul. 903, U. S. D. A., 1921. On wild grape. Cedar Point. July 17, 1912. W. W. Marshall, Coll.

Tribe *Chermesini*.

Chermes pinicorticia (Fitch). Bul. 173, Me. Agr. Exp. Sta., p. 303. On *Pinus strobus*. Columbus. April 15, 1920.

ECOLOGY.

Aphididæ show very definite relations to the factors of environment. These relations will be discussed under separate factors.

Edaphic Factors.

The structure temperature, water content, and probably the chemical composition of the soil has a direct bearing upon the presence or absence of certain root-feeding forms of Aphididæ. The more open types of soil are, for the most part, more favorable to the growth and multiplication of root-feeding aphis. In a planting of young peach trees on a hillside the absence of root-feeding form of *Anuraphis persicæ-niger* was noticed in heavy clay soil of the orchard, while all the trees in a gravely clay soil were infested with the species. In California the type of soil favorable to the growth and reproduction of the grape phylloxera (*Phylloxera vitifoliæ*) seems to be somewhat different.

Davidson and Nougaret[1] found that vines growing in heavy soils, more or less shallow, with compact clay subsoils, die out much sooner from the attack of the aphids than vines growing in well drained soils; that vines growing in very loose friable sandy soil, or one with a surface blow of sand several inches deep, seemed to be almost immune to the attack of the phylloxera.

Soil moisture definitely controls the rate of reproduction of the sugar-beet root-louse (*Pemphigus betæ* Doane). Parker[2] found in both field and laboratory experiments that the greater the moisture content of the surface soil the lower the rate of reproduction, and that migrating forms of the plant louse from *Populus* species showed a very decided preference for beet plants growing where the surface soil was dry.

Soil further determines the absence or presence of the Aphididæ by the influence exerted on the distribution and growth of the host plants.

Climatic Factors.

Temperature: Temperature has an extensive influence on the metabolism and reproduction of the Aphididæ. The time of hatching of the over-wintering eggs is determined by the

[1] Bul. 903, U. S. D. A., 1921, p. 16.
[2] Jr. Agr. Research, Vol. 4, p. 241-250.

early spring temperature. The growth and development of all forms are dependent upon temperature. The temperature factor is probably most marked in the development of the early spring generations in Ohio. Ewing[1] found that *Aphis avenæ* (*Rhopalosiphum prunifoliæ*) has its optimum development at a temperature of sixty-five degrees F., and that at ninety degrees F. development stopped. Headlee [2] found that a range in relative humidity of from thirty-seven to complete saturation had little effect on the development of *Toxoptera graminum* at a temperature of eighty degrees F.

Temperature change has an influence on the life cycle of Aphididæ. *Macrosiphum solanifolii* in Ohio begins the spring generation by the hatching of the stem mothers from the over-wintering eggs on rose. There follows viviparous parthenogenetic generations on rose and later on plants of the Solanum family, and with the coming of cold weather there is a return migration to the rose where the oviparous generation is produced and the over-wintering eggs are laid. Smith[3] has shown that in the coastal plains region south of Chesapeake Bay, Virginia, the oviparous forms are not known, but that the insect passes the mild winter as parthenogenetic, viviparous females. Gillette and Thomas[4] have shown that *Pemphigus populi-transversus* in its alternation from Populus to roots of cruciferous plants has a different behavior in the south than in the north. In the north the "true sex" forms are found in the fall and over-wintering eggs are laid, while in the south the "true sex" forms do not appear until spring and the eggs hatch soon after oviposition.

Air Movements: Air movements serve as a very important means of dispersal of all flying *Aphididæ*. Migrating forms carried by the wind are frequently noticed, especially in certain parts of the day. This means of dispersal adds greatly to the success of the species in that new host plants are found and some natural enemies are left behind. In a large field planted to peas which became heavily infested with the pea aphis (*Illinoia pisi*) the eastern part of the field seemed to be the more recent point of infestation. This seemed evident from

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[1] Biological Bulletin, Vol. 31, p. 53.
[2] Jr. Ec. Ent., Vol. 7, p. 416.
[3] Bul. 27, Va. Truck Exp. Sta., 1919.
[4] Jr. Agr. Research, Vol. 14, p. 577–593.

the fact that in the western part of the field the pea plants were entirely killed and the ground was covered with many dead aphids, while in the eastern part the pea plants were not entirely dead, and contained many living aphids. The afternoon and evening breezes of the locality are mostly from the west.

Air Moisture: Peterson[1] found that air of high moisture content is more favorable to the hatching of the eggs of *Aphis avenæ* (*Rhopalosiphum prunifolium*) than air of low moisture content. Hot dry winds are supposed to kill many Aphididæ.

Biotic Factors.

Food Relation: The food supply of Aphididæ has a definite effect upon the structure of the individuals. With a given host plant, in thrifty growing condition, the tendency in reproduction is to produce apterous forms only, but with drying up of the host plant the production of winged forms is the rule. It seems quite probable to the writer that the production of the "true sex" forms may be in a measure a response to a seasonal condition of the host plant.

Pergande[2] in his work with *Hormaphis hamamelidis* Fitch and *Hamamelistes spinosus* Shimmer showed these two species to have a most remarkable change of form associated with a change of habitat and food plants. The stem mothers and migrants from witch-hazel to the birch are of the ordinary aphid type. The first generation on the birch develop into aleurodian-like forms which in turn give rise to two more like generations. The last aleurodid-like form produces the return sexupare to the witch-hazel which are of the aphid type. Galls are produced on the witch-hazel by these species while no such growths are formed on the birch. The writer has not verified the life histories as given by Pergande, but has taken the various stages of the insects on witch-hazel and birch in several localities.

Association of Species.

It has long been known that in every aphid colony there is an association of other insects bearing a very definite relation to the plant lice. These insects may exist as predators, parasites, symbionts or guests of the species. The relation of the

[1] Bul. 332, N. J. Agr. Exp. Sta.
[2] Tech. Bul. 9, U. S. D. A.

symbionts may be somewhat complex as will be pointed out for ants of certain species in their relation to the *species Anuraphis maidiradicis* in its under-ground existence. Certain species of the families Tabanidæ and Muscidæ, species of Bombus, *Apis mellifera* Linn., together with the ants are attracted to the colonies by the presence of the sweetish excrement characteristic of many species of the Aphididæ. The predators and parasites add to the complexity of the community by introducing their parasites and hyperparasites. The following lists of species found associated in aphid colonies will give something of the complex.

In observations made on an association of insects acting as predators or parasites in colonies of *Macrosiphum solanifolii* the following species were reported by Houser, Guyton and Lowry:[1]

Predators—

Nine species of Coccinellidæ larvæ and adults as follows:

Hippodamia convergens Guer., *Coccinella 9-notata* Hebst.,
Hippodamia glacialis Fabr., *Coccinella sanguinea* Linn.,
Hippodamia parenthesis Say, *Megilla maculata* De Geer,
Hippodamia 13-punctata Linn., *Brachyacantha ursina* Fab.,
Adalia bipunctata Linn.

Three species of Syrphidæ larvæ as follows:

Syrphus americanus Wied., *Allograpta obliqua* Say,
Sphaerophoria cylindrica Say.

Larvæ of *Chrysopa* sp. were also predators.

Parasites—

Aphidus polygonaphis Fitch, *Pachyneuron aphidivorum* Ashm.
Two species of *Lygocerus*.
Diplazon laetatorius Fabr. and *Pachyneuron texanus* Gir.

The last two of the parasites named are parasites of the larvæ of syrphus flies.

Associated with this insect association were the following birds which acted as predators upon the insects:

Chipping sparrow (*Spizella passerina passerina* Bechstein), quail (*Colinus virginianus virginianus* Linn), English sparrow (*Passer domesticus* Linn), and the common fowl (*Gallus domesticus*).

It is undoubtedly true that many other species enter into the association, but the foregoing list is enough to show some-

[1] Bull. 317, Ohio Agr. Exp. Sta.

thing of the species which seem dependent upon conditions favorable to the growth and increase of *Macrosiphum solanifolii*, which in turn for best development depends upon plant growth and the comparative absence of its enemies.

Again much the same was noted in an outbreak of *Illinoia pisi* in a pea field in which all the pea plants are practically destroyed. Dead larvæ of Coccinellidæ, Syrphidæ and Chrysophidæ were common on the ground; and cases were common of cannibalism among like species. It seemed evident that the existence of the association, as such, depended upon the ability of the pea plants to keep living and produce a succulent growth for the maintenance of the aphid colonies, at least, one can safely say that the death of the pea plants hastened the breaking up of the intensity of the association, resulting in a more nearly normal number of species. The following list of species were taken in this field, the numerals after the species name are indicative of the proportion of occurrence:

The predaceous larvæ and adult forms of *Hippodamia parenthesis* Say (4), *Hippodamia 13-punctata* Linn. (1), *Hippodamia convergens* Guer (3), *Adalia bipunctata* Linn. (5), *Coccinella sanguinea* Linn. (2), *Coccinella 9-notata* Hebst. (2), *Coccinella transversoguttata* Fabr. (6).

The predaceous larvæ of *Syrphus ribesii* L. var. *vittafrons* Shan (5), *Syrphus rectus* O. S. (3), *Allograpta obliqua* Say (2), and the adult ground beetle *Lebia atriventris* Say (1).

The following Diptera were present in the association: *Leucopis nigricornis* Egger (6), a species reported as predaceous in the larval form on aphids.[1] *Distichona varia* V. d. W. was also taken, but its relation in the association was not determined.

The following Hymenopterous parasites were in much evidence in the association. The relative numbers of the species were not determined, but results of their activity were much in evidence: *Syrphoctonus agilis* Cress., *Aphidius rosæ* Hal, *Megorismus fletcheri* Cwfd., *Pachyneuron* sp., *Praon simulans* Prov., *Perilampus chrysopæ* and *Lygocerus* sp.

Of the above *Aphidius rosæ*, *Megorismus fletcheri* and *Praon simulans* are reported as parasites of aphids; and certain species of the genus Pachyneuron are also aphid feeders. Species of the genus Parilampus are reported as feeding on *Compoplex*

[1] New Series Bul. 10, U. S. D. A., p. 76.

fugitives, another species of Hymenoptera; as is a species of the genus Pachyneuron on *Diplazon* sp.

The following observation was made in an apple orchard April 9, 1919, between the hours of two and three P. M.

The day was clear and somewhat warm for that time of the year. Large numbers of the eggs of *Rhopalosiphum prunifolium* were hatched and the young migrated to the developing apple buds which were nearly ready to begin sending out leaflets. Something of the number may be gained from the count made of fifty-seven buds which contained 3,920 young aphids, or an average of nearly seventy to each bud. The following species were taken in or near the colonies, and in their larval or larval and adult stages are known to be predators of the Aphididæ.

Lady beetles were present in about the proportion of the numerals which follow the species name.

Coccinella 9-notata Hebst. (7), *Adalia bipunctata* Linn. (2), *Hippodamia parenthesis* Say (1), and *Coccinella sanguinea* Linn. (1).

Syrphus flies were represented by a single species, *Syrphus torvus* O. S., which was present on an average of six to each tree.

A species of saw fly of the genus *Selandria* was seen going over the colonies, but its relation was not determined.

From these brief studies a hint of the vast complex which exists in an association dependent upon the aphid colony becomes evident. Under average conditions of plant louse production a balance would be struck in which the activity of the host, predaceous forms, parasites and hyperparasites would tend to be equal. In the case cited of the pea field, it is evident that biotic and weather conditions were such that *Illinoia pisi* grew and increased quite rapidly. Toward the end of such a period of temporary success of a species the number of individuals in the association is greatly increased and the interdependence of the associated species magnified. The association in a particular plant group would tend to be much the same at all times and is only temporarily dominated by a particular species.

In so far as the writer knows there seems to be but few instances where aphid species are interdependent. *Phylloxera popularia* Perg. is found only in the galls formed by the genus Pemphigus and probably the existence of the species now depends upon the presence or absence of the Pemphigan galls.

There are many instances where it seems that aphids are dependent upon species of ants for success. The best known is probably the relation between *Anuraphis maidiradicis* and various ants, especially the corn field ant (*Lasius niger* L.). The ants collect the eggs of the plant lice in the fall and carry them down below the frost line in the ant's nest. With the coming of spring the young aphids are brought up to the roots of various grasses and weeds, and cared for by the ants. Many observers have noticed the ants carrying the aphids from corn plant to corn plant through the growing season, thus establishing new colonies. It seems likely that this relation has existed so long that the completion of the aphid's life cycle is dependent upon the ant's care.

Seasonal Succession.

The migration of Aphididæ from host to host seems to follow some seasonal change in the host plant. There are many instances of species spending the winter and the early part of the growing season on one host and then migrating for a period to one or many hosts, deserting entirely the primary host species. Later in the season there is a return migration from the secondary hosts to the primary host, where the "true sex" forms produce the fertilized, over-wintering egg. A good illustration of this is found in the behavior of *Anoecia corni*. The over-wintering and spring host is *Cornus* species, and the summer host is the grasses, especially orchard grass (*Dactylis glomerata*). The return migration in this species is rather late in the fall, taking place about the last week in October in the vicinity of Harrisburg, Pennsylvania.

At times the migration is not sharply defined, extending over a rather long period. Baker and Turner[1] pointed out an example of this in *Rhopalosiphum prunifolium* in its migration from and to the apple. In extreme cases the return migration is not complete, as in the case of the fall migration of *Eriosoma lanigerum* from apple to the elm. Here immature forms remain on the apple through the winter.

Ecological Succession.

With the change of plant covering of a given area there would come a change in the aphid population. The most

[1] Jt. Agr. Research, Vol. 18, p. 311.

important fact to support this statement is the very narrow limits of choice of host plants among the Aphididæ. With the passing of these host plants from an association the aphid species inhabiting such plants would follow the plants. Today are found certain groups of plant lice which are more or less restricted to particular groups of plants; as, for example, the tribe Lachnini, which for the most part is found on Pinaceæ, and the tribe Phylloxerini found for the most part on *Carya* species. With sufficient data of collections it seems probable that a given area might be plotted as to aphid species. At present we are undoubtedly safe in using the plant covering as an index to the species one might expect to find in a particular region.

ECONOMIC IMPORTANCE OF THE FAMILY APHIDIDÆ.

Species of the family Aphididæ occupy a major rank among economic insects. The loss in this country due to the attack of the spring grain aphis (*Taxoptera graminum*) for one year was estimated at from twelve to fifteen million dollars.[1] Plants are damaged by the loss of plant juices upon which the insect feeds through its sucking mouth parts.

Under favorable conditions the rate of increase among plant lice is very rapid. One producing female of *Macrosiphum solanifolii* was shown to be the parent of seventy-two individuals in twelve days, at which time five females were producing young.[2] Because of this rapid rate of reproduction a species may do very great harm in a very short period of time.

Still another mode of loss has been shown by proving the carrying of plant diseases from plant to plant by the feeding plant lice.[3]

Not only is there a loss occasioned by the direct attack of the species, but the cost of control measures amount to a large sum each year.

Of the list of Ohio species fifty-five species are known to be of economic importance in their attack on cultivated crops, and shade and forest trees.

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[1] Webster, F. M., Am. Ent. Soc. of Amer., Vol. 2, p. 70.

[2] Bul. 317, Ohio Agr. Exp. Sta., p. 65.

[3] Science, Vol. 56, p. 342.
Bul. 297, Me. Agr. Exp. Sta.
Jr. Agr. Research, Vol. 21, No. 1.
Bul. 303, Me. Agr. Exp. Sta., p. 340-343.

Aphids as Fruit Pests.

Aphididæ rank among the major insect pests of apple. The rosy aphis (*Anuraphis roseus*) stands first, injuring both fruit and foliage. This species may be especially harmful in the northern part of Ohio. The green apple aphid (*Aphis pomi*) is second of the species in rank attacking apple. This species attacks the newer growths, and is especially harmful to young trees. The wooly apple aphid (*Eriosoma lanigerum*) does a damage which is somewhat difficult to estimate, attacking the tree both above and below ground. Several other species may be found on apple. The apple-grain aphis (*Rhopalosiphum prunifolum*) is quite numerous on the apple in the fall and early spring, but probably does a minor injury. At times the green apple aphis (*Aphis pomi*) may do some damage to quince.

Young peach trees are frequently killed by an attack of the black peach aphis (*Anuraphis persicæ-niger*) on the roots. The writer's attention was called to a planting of four thousand trees of which one-fourth had been killed by the insect. The green peach aphis (*Myzus persicæ*) may at times do considerable damage to the foliage of the peach.

The foliage of the cultivated cherry is deformed into gall-like masses by the feeding of the black cherry aphis (*Myzus cerasi*). The damage done each year by this species is considerable. Plums are attacked by several species. The rusty plum aphis (*Hystroneura setariæ*) severely injures Japanese varieties, especially in the South. *Anuraphis cardui*, *Rhopalosiphum nymphaeæ*, *Phorodon humuli* and *Hyalopterus arundinis* may at times injure the foliage of plum.

Aphididæ in Relation to Grain Crop Production.

The wheat crop of this country, especially in the south and southwest in certain years, is threatened with total loss by the ravages of the spring grain aphis (*Toxoptera graminum*). As before mentioned, the loss to wheat in 1907 was estimated at twelve to fifteen million dollars. It is quite probable that this species is a controlling factor in the extension of the wheat belt southward. This species seem to be growing in destructiveness.

The corn root aphid (*Anuraphis maidiradicis*) ranks high as a pest of corn throughout the great corn belt of this country. The species seems to be generally present, and in sections where corn is followed by corn in the crop rotation may reduce the

yield as much as fifty to seventy-five percent. Corn and wheat as well as the other grain crops are injured by several other species, both as root feeders and blade and stem feeders. *Rhopalosiphum prunifolium*, the apple grain aphid, spends the greater part of the growing season in grasses. The writer has seen this species doing a considerable damage to young wheat in the fall before migrating to the apple. *Macrosiphum granarium* lives on a large number of the grasses and is rather common in the wheat fields of Ohio, but at present seems to be of minor importance as a grain pest. *Aphis maidis* at t mes does an injury to corn tops and may be quite serious in sweet corn plantings. No definite estimate may be made of the injury occasioned by several grass-feeding species, but they undoubtedly greatly reduce the yield in pastures and meadows.

Aphids Attacking Truck Crops.

Two plant lice stand out as major pests in two truck crops, either of which may if unchecked bring about a total destruction of the crop they attack. The pink and green potato aphis (*Macrosiphum solanifolii*) in 1917 killed out many potato fields in Ohio, especially was the destruction marked in the southwestern section of the state. This species has a very long list of host plants among which are potato, tomato, egg plant, pepper, and spinach. The establishing of the relation of this species to the spread of plant diseases make it of still greater economic importance.[1] The other of these two is the cucumber aphis (*Aphis gossypii*). Melon and cucumber growers suffer a very heavy loss from this species. Oftentimes the vines are killed outright just at the time when they should be producing their heaviest crop. *Aphis gossypii* does not feed on such an extended number of hosts as *Macrosiphum solanifolii*.

Cruciferous plants are attacked by the cabbage aphid (*Brevicoryne brassicæ*), and the false cabbage aphid (*Rhopalosiphum peseudobrassicæ*). These species become especially abundant on late plantings of cabbage, radish, and turnips. *Myzus persicæ* attacks a large number of truck crops, and may be especially harmful to potato plants. Several other species are found in the truck garden. The pea aphis (*Illinoia pisi*) in certain seasons may bring about a total destruction of pea plantings, and *Aphis rumicis* may at times be an important bean pest.

[1] Science, Vol. 56, p. 342.

Species of Aphids Attacking Small Fruits.

Blackberries and raspberries are hosts to a few species of plant lice. *Cerosipha rubifolii* causes a gall like twisting of the leaves of blackberry. P. C. Mason of the United States Department of Agriculture, in a private communication, reports three species of Amphorophora on raspberry. The writer has seen cultivated raspberries severely damaged by one of these species.

Several species of aphis play an important part in the growing of currants and gooseberries. *Myzus ribis* may cause a very heavy loss to currants by attacking the leaves, causing them to cup and curl, and to become characteristic reddish color. These leaves may fall and cause the fruit to be of poor quality. This species at times attacks the gooseberry. Of the other species found on these host plants *Amphorophora lactucæ* is probably most important. The Houghton gooseberry aphis may do considerable harm to the Houghton gooseberry, but does not seem to attack other of the Ribes.

Grapes are attacked by two species of aphids. The grape phylloxera (*Phylloxera vitifoliæ*) stands out as one of the most important insect pests of the grape, and it was this species that at one time threatened the grape growing industry of France, killing out two million acres of grapes before a control was discovered. Our native grapes seem to be more or less immune to its attack, but introduced varieties grown on the western coast suffer a very heavy loss each year from the attacks of this species. *Aphis illinoiensis* may at times do some damage to young grape vines by feeding upon and stunting the growth of the young arms.

The strawberry root louse (*Aphis forbesi* Weed) was described from Ohio, and is reported as quite injurious to strawberry plantings.

Aphid Species Attacking Shade and Forest Trees.

Probably less havoc is done to shade and forest trees by Aphididæ than to any other group of plants. The chermes attacking evergreens and phylloxera attacking deciduous trees, especially *Carya* species probably are the outstanding aphid pests of the forest. The elm serves as host to a number of species, several of which cause galls to form on the leaves. Species of maple when used as shade trees are at times over-run

by a number of species which may cause the foliage to become unsightly, and even drop in early summer. The number of species found on forest trees is very large.

Greenhouse Crops Injured by Aphids.

Many aphids found on plants outside may at times do injury to plants under glass. The chrysanthemum grower is quite sure to have trouble with a number of species. Roses, snapdragons, palms, ferns, lettuce, and cucumbers are at times severely infested when grown in greenhouses.

Control of Aphid Pests.

Natural Controls: Biotic enemies and adverse weather conditions make up the natural controls of the Aphididæ. Insects both as parasites and predators, several species of birds, and entomogonus fungi are chief of the biotic enemies. Extremes of heat or cold at a particular season of the year, and heavy rains kill off large numbers of Aphids.

Cultural Practices in Control of Aphids: Crop rotation will do much in control of certain aphid pests. The growing of plants which do not serve as host to the depredating species will tend to clean up the infestation. The destruction of weeds which serve as host to the species will reduce the numbers and help to prevent spread of the species to neighboring crops. Crop remnants should be destroyed soon after harvest to prevent migration from such material to growing crops. Thorough cultivation will break up the nests of aphid-attending ants, and thus protect the crop from root feeding forms.

Artificial Control Measures: Most effective of the artificial control measures for Aphididæ is the use of nicotine, preferable as a sulphate salt carried to the plant either in a dust or in a water solution. Oil emulsions may be used, but greater skill is required in preparing the spray and making the application than with the nicotine.

In greenhouses fumigation with hydrocyanic acid gas or with fumes of nicotine is successful as aphid control.

Recently attention has been directed toward the destruction of intermediate hosts. (See Bulletin 303, Maine Agricultural Experiment Station, 1921). This method is of much value where but one over-wintering host is known for a destructive aphis species. Further development depends upon a more thorough study of the life cycles of economic species.

Received for publication, May 16, 1923.